Before the
Federal Communications Commission
Washington, DC 20554

In the Matter of	)	
	)	
Establishment of an Interference Temperature Metric to Quantify and Manage Interference and to Expand Available Unlicensed Operation in Certain Fixed, Mobile and Satellite Frequency Bands	)	ET Docket No. 03-237

COMMENTS OF AT&T WIRELESS SERVICES, INC.

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Pursuant to Section 1.415 of the Commission's rules,[1] AT&T Wireless Services, Inc. ("AT&T Wireless") respectfully submits these comments to the *Notice of Inquiry* ("*NOI*") in the above-captioned proceeding.[2]

INTRODUCTION AND SUMMARY

AT&T Wireless appreciates the Commission's interest in increasing spectrum efficiency and creating additional opportunities for unlicensed use while attempting to provide additional certainty for incumbent licensees. However, AT&T Wireless has a number of concerns with the concepts described in the *NOI*, and does not believe that the interference temperature concept can be effectively implemented in bands used by mobile services, including the Commercial Mobile Radio Service ("CMRS"). If an interference temperature limit were established in the CMRS bands, wireless customers would experience reductions in coverage, capacity, and overall service quality. Violations of an interference temperature limit by underlay devices are also a serious

[1] 47 C.F.R. §1.415(c) (2002).

[2] *Establishment of an Interference Temperature Metric to Quantify and Manage Interference and to Expand Available Unlicensed Operation in Certain Fixed, Mobile and Satellite Frequency Bands*, FCC 03-289, *Notice of Inquiry and Notice of Proposed Rulemaking*, ET Docket No. 03-237 (rel. Nov. 28, 2003) ("*NOI*").

concern due to their potentially widespread adoption and the lack of control over what are expected to be consumer devices. Based on the Commission's past experience with other types of unlicensed devices, AT&T Wireless believes that the current rules do not provide the level of enforcement needed and that devising appropriate enforcement mechanisms for policing underlay interference will be exceedingly difficult. Rather than producing certainty, the interference temperature concept as described in the *NOI* will actually cause a higher level of uncertainty and concern—over the assumptions underlying the concept, its practicality, the increased levels of interference that could occur as a result of the proliferation of underlay devices (and the resultant harm to consumers and operators), and the lack of effective recourse if harm were to occur.

I. THE COMMISSION MUST STRIKE A PRINCIPLED, NEUTRAL BALANCE BETWEEN LICENSED SERVICES AND UNLICENSED APPLICATIONS.

As the Commission continues to explore new opportunities for unlicensed devices, it must ensure that the policies it develops are based on sound principles of spectrum management. In particular, the Commission should identify opportunities for unlicensed applications to be tested and developed in spectrum dedicated to that use. The Commission should also reinforce its long-standing policy of technology neutrality. Promoting the development of unproven unlicensed technologies at the expense of licensed services would ill serve consumers, seriously undermine incentives for continued innovation, and constitute a step back toward the failed industrial policies of the past.

A. New Interference Temperature Applications Are Best Developed in Spectrum Dedicated to Unlicensed Use.

As the Spectrum Policy Task Force noted, "sufficient interference protection is a necessary and fundamental building block in any spectrum policy."[3] Unfortunately, as shown

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[3] *See* Spectrum Policy Task Force Report, ET Docket No. 02-135, (rel. Nov. 15, 2002) ("SPTF Report") at 25.

below, the interference temperature concept described in the *NOI* does not provide that protection.

In recognition of the difficulties in protecting incumbent licensed services, AT&T Wireless previously expressed support for the Spectrum Policy Task Force recommendation that the Commission primarily adopt the exclusive use model in spectrum below 5 GHz and identify spectrum dedicated to unlicensed use in higher bands.[4] Making available additional spectrum dedicated to unlicensed use would serve two important goals: it would provide a suitable testing environment for developing technologies based on the interference temperature concept free from the limitations imposed by interference protection requirements, and it would protect existing services from interference and ensure continuing innovation in those services. The Commission should facilitate the use of the higher frequency bands by unlicensed devices rather than attempt to "shoehorn" new underlay operations into intensively used spectrum bands. AT&T Wireless once again urges the Commission to set aside future bands of spectrum for unlicensed use, particularly in higher frequencies.

B. The Commission Should Not Pick Technology Winners or Create Spectrum Losers.

A setaside of underlay space within licensed spectrum would also amount to the favoring of one set of technologies and users (unlicensed) over another (licensed). By effectively taking spectral resources away from existing licensed users and reserving it for unlicensed applications,[5] the Commission will have chosen to promote unlicensed applications at the expense of licensed

[4] *Id.* at 39. *See* Comments of AT&T Wireless Services, Inc., *Commission Seeks Public Comment on Spectrum Policy Task Force Report*, ET Docket No. 02-135 (Jan. 27, 2003) ("AT&T Wireless SPTF Report Comments") at 3-4. *See also* Reply Comments of AT&T Wireless Services, Inc., *Additional Spectrum for Unlicensed Devices Below 900 MHz and in the 3 GHz Band,* ET Docket No. 02-380 (May 16, 2003) ("AT&T Wireless 900 MHz Reply Comments") at 7.

[5] *See infra* section III.B.2.

users. Such an action assumes that the Commission has the foresight to know what will be the most innovative, useful, and successful technologies and applications.

The forces of a competitive marketplace are already ensuring that CMRS spectrum is used efficiently and are driving ever more intensive use of this limited resource.[6] Rather than substituting its judgment for the discipline of the market, the Commission should let the forces that have driven innovation in the CMRS industry continue to work. Those forces are taking the industry closer to—and below—the noise floor in an attempt to enhance efficiency, increase capacity and improve service quality. Imposition of the interference temperature concept in the CMRS bands could take resources from a successful service that is using them effectively and effectively dedicate them for use by devices that are conceptually and practically suspect. Allocation of resources in such a way would threaten innovation going forward.

II. THE INTERFERENCE TEMPERATURE CONCEPT WILL NOT WORK IN CMRS BANDS.

In describing the interference temperature concept, the Commission makes a number of technical assumptions that are either misleading or inapplicable to CMRS systems. When these misperceptions are factored together, it is clear that the interference temperature cannot be practically applied in the CMRS bands.[7]

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[6] The billions of dollars that have been spent acquiring CMRS licenses give operators every incentive to ensure that the resource is used as intensively as possible. The CMRS community has responded by putting enormous time and effort into the development of technologies that will maximize this investment. *See infra* section III.B.1.

[7] AT&T Wireless's position is an affirmation of the *NOI's* notation that the interference temperature concept "may not be feasible in all bands." *See NOI* at ¶ 18, noting the SPTF Report.

A. The Premises Underpinning the Interference Temperature Concept are Faulty.

1. Characterization of the RF environment from the victim receiver's perspective is not possible.

One of the threshold assumptions on which the interference temperature concept rests is that the RF environment[8] can be adequately measured, analyzed and described so that unlicensed devices would be able to determine when they could operate and at what power levels. The *NOI* notes the importance of understanding the RF environment ("noise floor") as a basis for setting an interference temperature limit, and further defines "N" as the "cumulative environmental RF energy…generally present around the receiver's antenna."[9] AT&T Wireless concurs that an understanding of the noise floor would be important in making the interference temperature concept work, and appreciates the Commission's recognition that the relevant locale for meaningful measurement of noise is at the receiver's location. However, for unlicensed devices to effectively protect a victim receiver, the unlicensed device must be able to determine not only the RF environment "around" the licensed receiver, but also the interference the receiver is actually experiencing at any point in time and space. In practice, neither of these factors can be captured effectively or accurately.

The Commission appears to assume that external interference ("I+N")—shown in Figure 1 of the *NOI* [10] as the original noise floor plus the interference spikes—is the primary cause of

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[8] For purposes of these comments, AT&T Wireless understands the Commission's use of the terms "RF environment" and "noise floor" to be synonymous and to represent all RF energy from both natural and man-made unintentional noise sources ("N") plus interference from intentional transmitters ("I"). The "interference temperature" in this context is a quantitative measure used to describe the real-time condition of the RF environment.

[9] *NOI* at ¶ 24. Similarly, AT&T Wireless assumes that the Commission would also agree that the interference from intentional radiators ("I") would also be present around the receiver's antenna.

[10] *Id.* at ¶ 15.

interference to a licensed receiver.[11] Based on this assumption, the Commission therefore concludes that the RF environment only need be measured "around" the victim receiver. However, in reality it is not possible to measure the effect of any type of interference on a victim receiver unless the RF environment is analyzed from *within* that receiver—as it is actually being experienced by the device. To create an internal description of its interference environment, the victim receiver must first remove as much of the dominant and predictable (intra-system) interference as possible; only then can the receiver analyze for itself the RF environment in which it is operating. Based on that knowledge and on what is happening internally, the victim receiver could then characterize the complete operating environment. No device or system external to the victim receiver can see inside a victim receiver in this way.

Furthermore, even if analysis of the RF environment in the vicinity of the victim receiver were all that was needed, the interference temperature concept still would be unworkable in the CMRS bands. As AT&T Wireless and others have previously noted, the actual noise floor varies greatly by specific location, time of day, and frequency.[12] These variations make the development of a accurate picture of the RF environment almost meaningless, especially over long periods of time, as noise and intentional radiator levels are constantly changing. The Spectrum Policy Task Force Report acknowledges the extreme difficulty of accurately assessing the environment based on interference from RF sources that "may not be known or anticipated."[13]

This fact has two important consequences for the interference temperature concept. First, it would be unwise to base an interference temperature limit on a measurement (the interference

[11] As defined in the *NOI*, interference temperature is "a measure of the RF power generated by undesired emitters plus noise sources that are present in a receiver system (I+N) per unit of bandwidth." I (interference) is defined as emissions from intentional transmitters (e.g. out-of-band emissions and co-channel interference), while N (noise) represents the aggregate energy that exists at the antenna, and which is produced by "atmospheric conditions, galactic sources, and man-made incidental and unintentional radiators." *Id* .at ¶¶ 10, 24.

[12] *See* AT&T Wireless SPTF Report Comments at 10-11.

[13] *See* SPTF Report at 18.

temperature) that cannot be accurately or precisely described, and, more importantly, a measurement that therefore cannot be transposed into a meaningful, generalized number. Without a firm foundation on which to build, the establishment of any interference temperature limit would be nothing more than a “best guess” that would probably not reflect real world operating environments.

Second, natural variations in noise and interference make it impossible to know what the interference temperature is at the *exact* location of the victim receiver. In the case of CMRS devices, this problem is further complicated by the mobile nature of the subscriber equipment, which introduces a non-constant spatial variation. Although the Commission defines the area around the victim receiver’s antenna as the only relevant location for assessing the external (as opposed to within the receiver) RF environment—which AT&T Wireless generally agrees with—it is unclear how the Commission reconciles its that definition (referring to the receiver’s specific location) with the necessarily more generalized determination of the interference temperature the *NOI* then describes.[14] In order to prevent interference to licensed devices from unlicensed underlay devices and applications, it is not sufficient to know where the licensed devices are located because the specific RF environment around the receiver is still not known. And it is neither necessary nor sufficient to know what the interference temperature is at the unlicensed device; that is irrelevant to how much noise/interference the licensed device(s) are exposed to at any given point in time—and whether an unlicensed device should operate or at what power. As a result, unlicensed underlay devices and systems that might work in a “listen before talk” mode will be ineffectual in limiting interference because they are only listening where they (or monitoring stations) are, not where the victim receiver is located or will be located during the unlicensed transmission.

[14] *See NOI* at ¶¶ 11-12. The Commission defines a specific location requirement for “N,” but then proposes to measure (and report on) the interference temperature in larger regions.

The Commission has apparently recognized this fact in paragraph 10 of the *NOI,* in which the Commission states that "measurements would be taken at various receiver locations" and subsequently that a "system would be needed to measure the interference temperature in the band and communicate that information to devices subject to the limit…."[15] Unfortunately, none of the three scenarios the Commission then describes solves the fundamental problem of assessing the interference temperature in the CMRS bands because none of the three solutions measures *at the mobile victim receiver*, and so cannot assess the RF environment in which the mobile receiver is actually operating.[16] Without such knowledge, an unlicensed device cannot make a valid decision on whether to transmit and at what power. Likewise, the Commission's specific questions on approaches to be used for measuring the interference temperature are misplaced as they are based on the faulty assumption that regional/area measurements would be sufficient to gauge the RF environment at all locations within the area.[17]

2. Capacity and service quality are at least as important as range in CMRS system design.

The interference temperature concept, as illustrated by Figure 1 in the *NOI*, assumes that the principal performance parameter of a system is range/coverage at the cell edge. While it is true that CMRS operators engineer their networks to provide acceptable service quality at the farthest absolute distance from each cell transmitter, because of customers' increasing propensity to use their wireless devices indoors, there are coverage challenges throughout the entire cell area (*e.g.* elevator in an office building, basement in a residence, etc.) regardless of the absolute

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[15] *Id.* at ¶¶ 10-14.

[16] *Id* .at ¶ 11. In the first case the Commission describes, the unlicensed device measures only its own location; in the second and third cases, a collection of data is assembled and generalized for a region or area, a degree of granularity far too high to be useful by individual CMRS receivers at specific locations.

[17] *Id.* at ¶ 22.

distance from the cell center. In these situations, the specific characteristics of the location cause system performance to be similar to that experienced at the actual cell edges.[18]

Contrary to the *NOI's* premise, however, the primary design consideration in the majority of AT&T Wireless's service area is system capacity (the extraction of the maximum information transmission rates from the available signal-to-interference ratio (S/I) at any given geographic location), not coverage. Figure 1 in the *NOI* also appears to assume that external interference ("I"+"N") is the main source of degradation in system performance. In the case of CMRS, however, the dominant source of interference—and the main constraint on system capacity—is the interference generated by the system itself (intra-system interference). CMRS operators very carefully analyze such interference and take steps to mitigate it through the use of capacity maximizing techniques, including power control and self-interference cancellation. Within the receiver, for example, single antenna interference cancellation (SAIC) works by canceling intra-system interference based on the known characteristics of the GSM signal.

In fact, there are several interference suppression techniques available in different technology standards that cancel co-channel interference and increase spectrum efficiency by keeping intra-system interference to the minimum level. Importantly, these interference cancellation techniques rely on prior knowledge of the system's modulation and other parameters; they are successful only because they are able to anticipate the interference they will see. Absent such knowledge, these techniques will be ineffective against other sources of interference, and thus would be of little use in addressing the type of unpredictable interference that would be caused by underlay devices.

Under the interference temperature concept, therefore, intra-system interference would likely no longer be the primary source of interference; underlay devices operating up to the interference temperature limit would become the dominant interference factor. If the interference

[18] The reductions in coverage caused by interference temperature limits are discussed in Section III.A.

level in the system came to be dominated by external sources, there would be no benefit to reducing the power levels used (in contrast, there would likely be more incentive to increase power to compensate for underlay interference) and no way for the receiver to cancel interference of an unknown type. In short, the intra-system interference previously mitigated by the receiver would simply be replaced by interference from external sources—the receiver would encounter the same or higher levels of interference without any ability to correct for it, thus forcing lower capacity and/or reduced coverage. Complicating the interference scenario further is the likelihood of a wide variety of underlay equipment; hundreds of different types of devices—all with varying technical characteristics and parameters—may be operating in licensed bands. It is neither practical nor possible to program CMRS devices to deal with such a constantly changing universe of unlicensed devices.

Although the above discussion primarily assumed voice communications, imposition of an interference temperature limit will also negatively affect the capacity of advanced data systems as well as voice systems. Adaptive systems such as Enhanced Data rates for Global Evolution ("EDGE") adjust their modulation and channel coding to maximize spectral efficiency/capacity by making best use of the available S/I. If S/I is reduced through the imposition of an interference temperature limit, fewer users will be able to be served at a given data rate. In reality, because the overall system capacity is shared among users, and operators want to maximize the number of customers they can serve, the network will compensate for the reduced S/I by reducing the data rate available to each user. In short, an operator is forced to accept either lower capacity or reduced data transmission rates, and users will either experience lower data rates or higher incidences of blocked sessions.

Finally, in suggesting that a single interference temperature limit could be applied in a specific band (*e.g.* the CMRS bands), the Commission appears to assume that all mobile systems would be equally impacted by the limit. Unfortunately, this is not the case. Analog, TDMA, GSM, GPRS, EDGE and the various types of networks based on CDMA technology all have different technical characteristics (power schemes, modulation and coding, noise tolerances) and different abilities to mitigate external noise. Thus, some (types of) networks will be more negatively affected than others by the introduction of underlay devices. These differences will be reflected in the efforts that the operators of each technology would have to make to overcome the impacts of the interference temperature limit, and potential disruptions to service.

3. CMRS carriers already use the space that the Commission believes represents "New Opportunities for Spectrum Access."

Based on the above design considerations, and contrary to the Commission's assumption, it is clear that CMRS operators already use the space labeled "New Opportunities for Spectrum Access" in Figure 1 of the *NOI*. This "unused" space in reality is the operators' opportunity to utilize the spectrum most efficiently, to ensure that calls will be successful in worst case RF conditions, and to maximize system capacity for voice and data when the RF conditions are more favorable. Progress is being made in the various standards bodies to keep the threshold labeled in the *NOI's* Figure 1 as "Minimum Service Range with Interference Cap" as close as possible to the "Original Noise Floor Margin," and in the case of CDMA technologies, below the noise floor, as discussed below.

The *NOI* refers to the margin that is incorporated in the system design.[19] This could be in the form of fade margin or C/N or Eb/No or load factor. These margins are provided by operators to account for system interference and to provide coverage to the user at the cell edge. To return to the EDGE example, when a user is close to the cell site, the full S/I margin is efficiently utilized by the system—through innovative receiver design and adaptive modulation techniques—to provide the highest possible data rates. These techniques are part of the industry standards for both EDGE and High Speed Data Packet Access ("HSDPA"). Variable coding schemes (MCS9-MCS1, see Figure 1) make the most of the available S/I at any given point.

[19] *See NOI.* at ¶ 27.

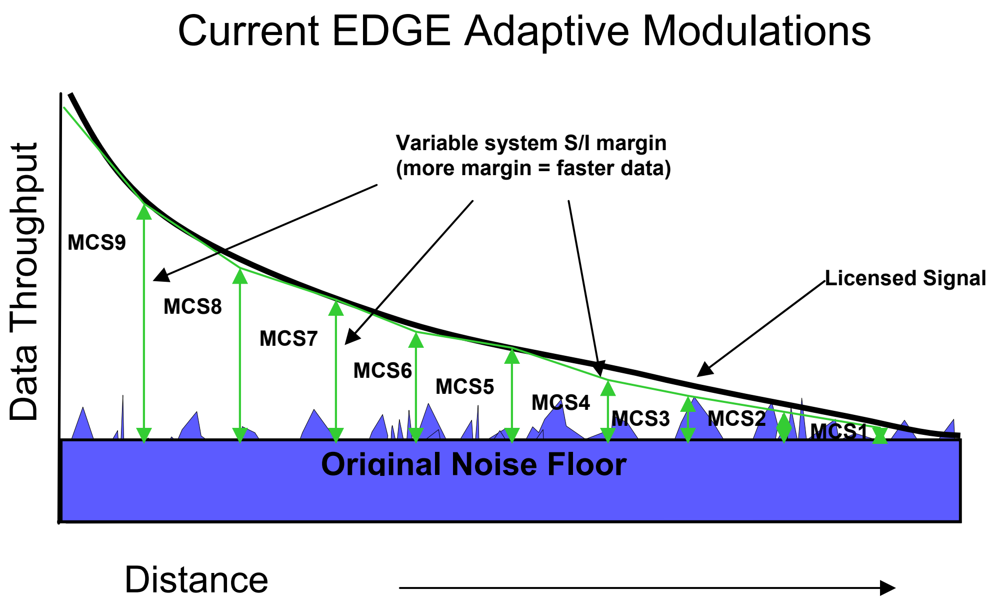

Figure 1

Across the range for each coding scheme, there is variable S/I, but the error correction that is added in the higher layers of the protocols converts what would be a "step" function to a smooth variation of data rate with S/I. At the poorer S/I end of each coding range (farther from the cell site), more error correction is used, which reduces the overall data throughput. At the very edge of the cell (and in the most challenging coverage conditions within the cell) where signal strength is lowest, the margin is fully used to provide the minimum acceptable service (MCS1). In between the cell center and cell edge, whatever margin is available is used to provide the optimal performance for that location and signal conditions.

CDMA systems, including the W-CDMA technology AT&T Wireless is developing, offer another example. CDMA systems by design operate *below* the noise floor and the carrier can be much below the KTB level depending upon the processing gain and the Eb/No requirement of the channel. Defining an interference temperature limit based on KTB assumes that the antenna noise is below (better) than the receiver sensitivity of the system (true for GSM & IS-136 systems). But for W-CDMA systems, due to processing gain, the antenna noise is above (worse) than the receiver sensitivity. If an interference temperature limit were imposed, this would allow unlicensed users to generate interference at levels higher than the incumbent systems receiver sensitivity resulting in an effective increase in the noise floor directly causing capacity degradation or coverage reduction in the system.[20]

B. Technology to Implement a Workable Interference Temperature Limit Does Not Exist.

From a practical standpoint, the interference temperature concept requires technology that does not exist. As AT&T Wireless and others have pointed out, no practical, commercially-available solutions currently exist that will overcome the interference issues identified in the *NOI*, especially as these issues apply to licensed mobile services, including CMRS.[21] Refuting claims by some that such technologies are available or soon will be, the Association for Maximum Service Television, Inc., the National Association of Broadcasters, and the Association of Public Television Stations have noted that,

> [t]echnologies allowing unlicensed devices to detect spectrum availability and, if necessary, to change frequencies in order to avoid interference are still in development and certainly have not been subject to the rigorous testing needed to determine whether they are effective in preventing interference in real-world settings . . . .[22]

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[20] In CDMA, coverage and capacity are inextricably linked. An increase in noise within the mobile receiver (*e.g.* from unlicensed underlay devices) must be overcome by more transmitted power from the base station. Since the base station is power limited, if it is not at load, it can allocate more power to the interfered mobile and overcome the interference, essentially maintaining the coverage for that mobile. If the base station is at load, it cannot allocate more power to the interfered mobile without reducing power available for others. So, if the base station wants to maintain design capacity and cannot allocate more power to the interfered mobile, the interfered mobile becomes a dropped call and overall capacity is reduced.

[21] *See* generally AT&T Wireless SPTF Report Comments at 11; *see also* AT&T Wireless 900 MHz Reply Comments at 6.

[22] *See* Comments of MSTV/NAB/APTS, Additional Spectrum for Unlicensed Devices Below 900 MHz and in the 3 GHz Band, ET Docket No. 02-380 (May 16, 2003) at 3.

AT&T Wireless agrees with these comments and the comments of the Land Mobile Communications Council, which note that regulatory decisions "based on anticipated advances in technology are dangerous, and should await the demonstrable existence of such technology at reasonable costs for widespread deployment."[23]

Others have identified the difficulties that would occur if unlicensed operations were introduced in frequency bands used for mobile services. Motorola, for example, noted:

> In general, [with] the dense spectral reuse, area licensing with no database of individual base stations, and high degree of mobility for mobile and portable radios . . . there is no readily apparent technological solution that would enable unlicensed secondary use without causing harmful interference to licensed services.[24]

And even Intel, a supporter of the unlicensed devices has observed, "the static, fixed nature of TV broadcasting makes sharing much easier than would be the case for services operating on an intermittent or mobile basis."[25]

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[23] *See* Comments of the Land Mobile Communications Council, *Additional Spectrum for Unlicensed Devices Below 900 MHz and in the 3 GHz Band,* ET Docket No. 02-380 (May 16, 2003) at 5 (quoting TIA Comments to the Spectrum Policy Task Force Report in ET Docket No. 02-135, at 3 (Jan. 27, 2003)).

[24] *See* Comments of Motorola, Additional Spectrum for Unlicensed Devices Below 900 MHz and in the 3 GHz Band, ET Docket No. 02-380 (May 16, 2003) at 5.

[25] *See* Comments of Intel Corporation, Inc., *Additional Spectrum for Unlicensed Devices Below 900 MHz and in the 3 GHz Band*, ET Docket No. 02-380 (May 16, 2003) at 7.

III. SIGNIFICANT HARM WOULD RESULT FROM UNLICENSED UNDERLAYS IN THE CMRS BANDS.

The previous section outlined some of the theoretical limitations and practical barriers to the interference temperature concept, and the near certainty that interference to existing licensed systems will occur. In addition to such problems, the Commission must be aware that there will be serious technical and economic impacts on licensed systems, *even if the interference temperature concept works as the theory would predict.* Regardless of interference, the imposition of an interference temperature limit would degrade existing CMRS systems in terms of coverage, capacity, and consumer experience; and would undercut industry efforts to improve spectrum efficiency going forward.

A. Coverage, Capacity, and Service Quality Would Be Reduced.

The Commission recognizes the practical impacts of an interference temperature limit on coverage in Figure 1 of the *NOI.*[26] It is clear from that figure (as modified in Figure 2 below to show the "Service Area Reduction" explicitly), that the service range of a licensed system will be reduced by the imposition of an interference temperature limit.

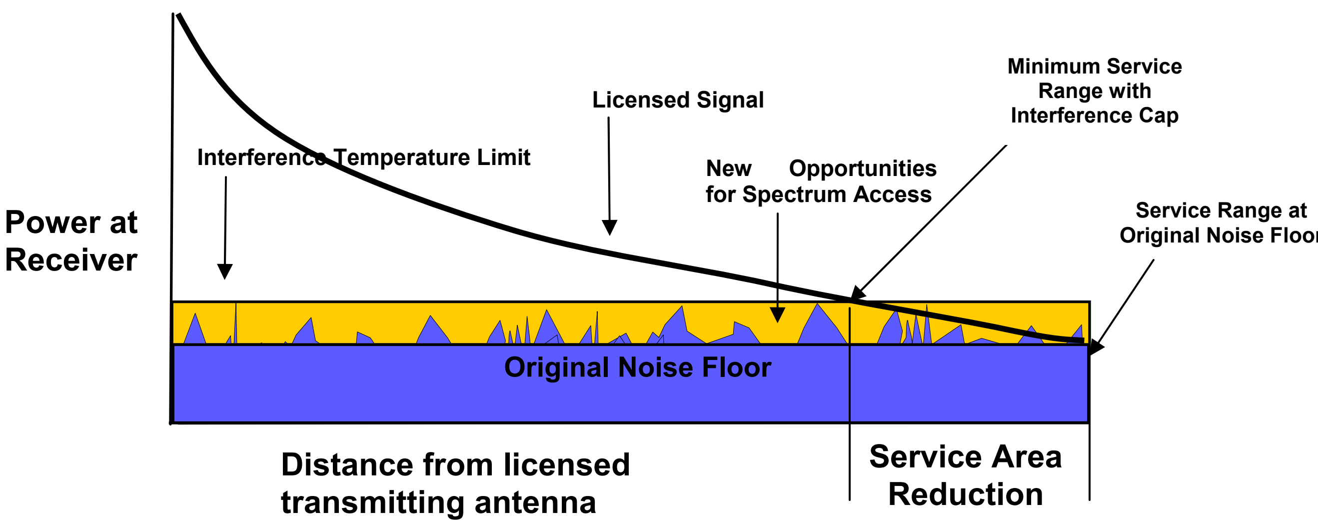

Figure 2

[26] *See NOI* at ¶ 15.

Seen from another perspective, the imposition of an interference temperature will create gaps in coverage where none exists today. See Figure 3.

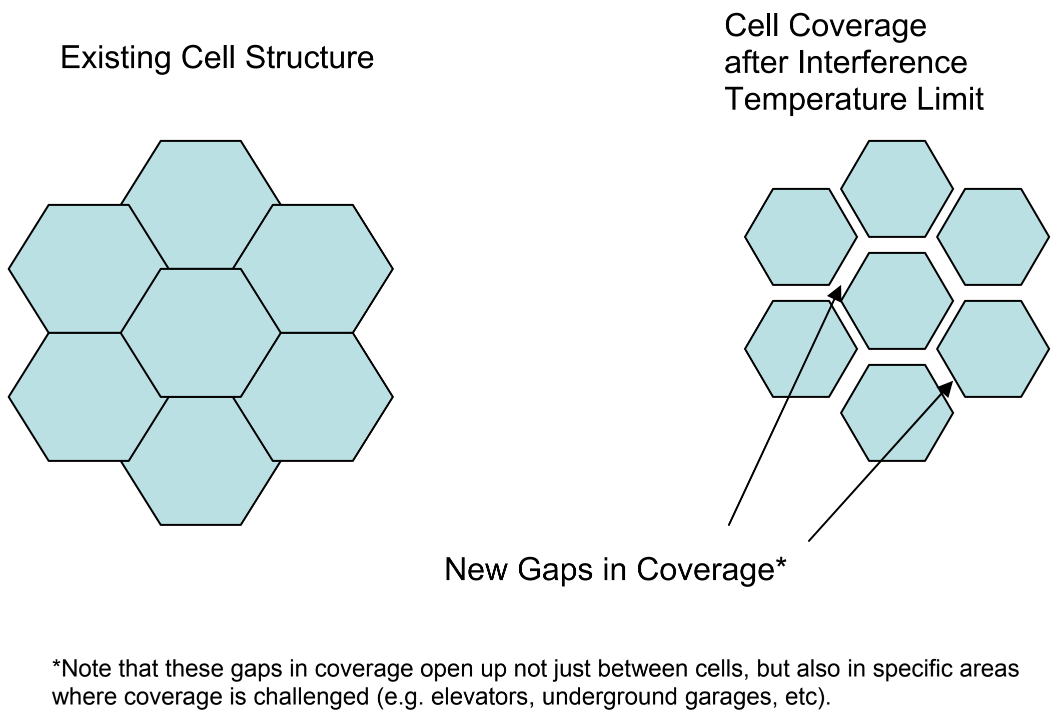

Figure 3

The impact on data services specifically could be quite severe. In an EDGE system, the imposition of an interference temperature limit, as shown below in Figure 4, would reduce the S/I margin, leading to both coverage and service quality degradation.

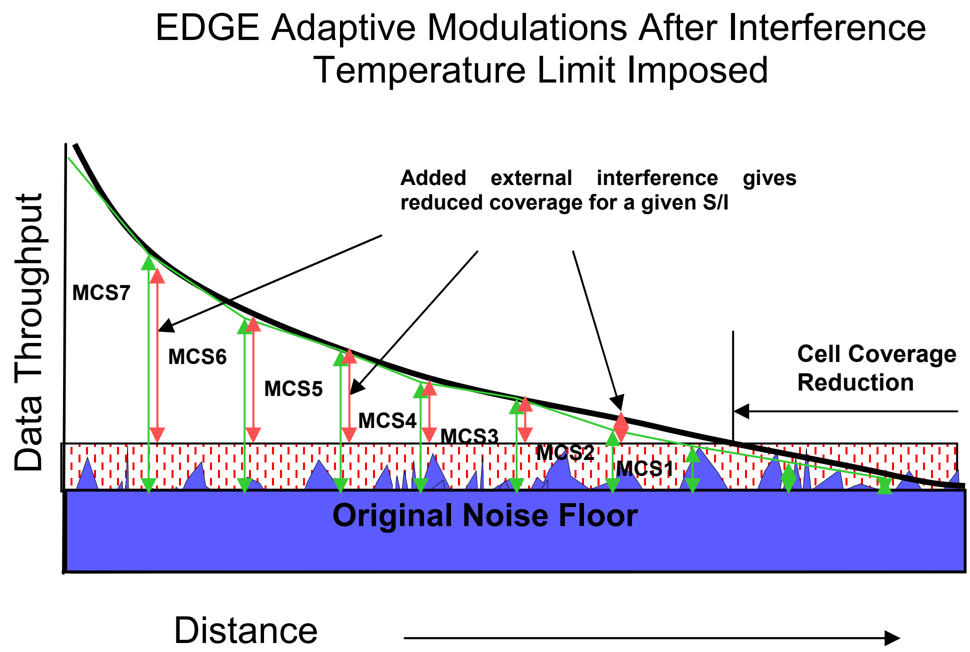

Figure 4

Figure 4 also makes clear that not only will a user experience lower data rates, but that in some cases data connectivity may not be available (at any speed) where it had been before.

To further clarify and quantify the actual impact that might occur, AT&T Wireless performed initial calculations based on several levels of degradation to the noise floor in a GSM environment. Network level simulations and link budget analysis were used to translate link level losses to coverage/capacity reduction.[27] In a coverage-limited system typical in a suburban setting, for a 1 dB degradation of the noise floor, the coverage loss is approximately 15 percent and a 2 dB degradation results in a coverage loss of 25 percent.[28] Faced with such a loss of coverage, AT&T Wireless would be forced to reengineer the frequency plan for the network,

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[27] *See* Timo Halonen, Javier Romero, Juan Melero, eds., GSM, GPRS and EDGE Performance Evolution Towards 3G/UMTS, Appendix C (2002).

[28] According to the link budget calculations, the cell radius of a suburban site is approximately 2.4 km with a cell area of 18.08 km^2. 1 dB of link loss results in the reduction of cell radius to 2.2 km with the corresponding decrease in cell area to 15.37km^2. Correspondingly 2 dB of link loss would result in further decreasing the cell radius and cell size to 2.1 km and 13.56 km^2, respectively.

adjust existing sites, and/or build additional cell sites just to restore the coverage area to pre-interference temperature limit levels.[29] Table 1 below provides a simple example that quantifies the impacts of an interference temperature limit on a hypothetical suburban/rural GSM system consisting of 100 cell sites.

	Cell Area	**Total coverage for 100 sites**	**Loss of coverage**	**Additional sites required**
0 dB degradation (pre interference temp.)	18.08 sq km	1808 sq km	None	None
1 dB degradation	15.37 sq km	1537 sq km	271 sq km	17
2 dB degradation	13.56 sq km	1356 sq km	452 sq km	33

Table 1

This table shows that in a suburban or rural setting 17 additional cell sites would have to be built (271 sq km to be replaced/15.37 sq km per additional cell site) to recover from a 1dB degradation, a 17 percent increase. Correspondingly, 33 (452/13.56) more sites (38 percent increase) would be required to recover the original footprint with a 2 db degradation in the link margin.

In an urban environment, which is capacity-limited as opposed to the noise-limited suburban/rural case, capacity loss would be the primary harm from underlay devices. Capacity losses in a GSM system are approximately 25 percent and 40 percent for 1 dB and 2 dB link loss, respectively. Table 2 provides a simple example of the capacity loss that would occur in a hypothetical GSM urban network consisting of 100 cell sites and calculates the additional sites that would be required to maintain existing capacity levels.

[29] Customers' expectations about service quality, federal mandates such as E-911, and homeland security imperatives like wireless priority access all emphasize the importance of maintaining and expanding coverage and capacity.

	Erlangs/Cell[30]	**Total Erlangs for 100 sites**	**Loss of Erlangs**	**Additional sites required**
0 dB degradation (pre interference temp.)	50 Erlangs	5000 erlangs	None	None
1 dB degradation	37.5 Erlangs	3750 erlangs	1250 erlangs	33 sites
2 dB degradation	30 Erlangs	3000 erlangs	2000 erlangs	66 sites

Table 2

A 1 dB and a 2dB loss would require an additional 33 percent and 66 percent increase in cell sites respectively in the urban GSM case. Implementing a interference temperature threshold would thus result in a profound impact on system capacity, as each cell would now be able to carry only a fraction of the traffic it was designed to carry.

For a national operator such as AT&T Wireless, the effort and cost required to re-engineer the network and add the required cell sites would add up quickly. AT&T Wireless has emphasized before that:

> [i]ncumbent licensees should not be compelled to adjust their operations in order to avoid interference from unlicensed users. Such action would ill-serve the Commission's goal of efficient spectrum utilization by raising substantial uncertainty regarding the rights accorded to licensees. The Commission must act deliberately and prudently in considering novel unlicensed operations to ensure that licensed users are protected from harmful interference.[31]

At a time when operators are deep into the process of upgrading to next generation systems, forcing the industry to commit this level of effort and funding *just to maintain existing coverage and capacity* would be an uneconomic use of scarce capital, and would undermine the very advances the Commission seeks to promote.

Absent efforts to restore coverage and capacity to pre-interference temperature levels, the service quality levels experienced by customers will also deteriorate in predictable ways. As shown in Figures 2 and 3, in areas where service quality existed at minimum acceptable levels

[30] Assumes 20 erlangs per sector and 2.5 sectors per cell.

[31] *See* AT&T Wireless 900 MHz Reply Comments at 6.

before the interference temperature limit, after its introduction, signal strength would be inadequate to provide any acceptable service. Likewise, areas that previously experienced good service quality may now experience only acceptable service quality levels (the curve of Figure 1 in the *NOI* has been essentially shifted to the left). Similarly, for data, Figures 1 and 4 describe the EDGE example of how service quality is reduced as S/I is reduced—as a function of distance naturally (Figure 1) or as the result of the imposition of an interference temperature limit (Figure 4).

B. Interference Temperature Limits Will Undermine Future Innovation.

Immediate impacts aside, the Commission must also consider the long-term consequences of any use of the interference temperature concept in the CMRS bands. As part of its overall spectrum management responsibilities, two of the Commission's most important goals are to promote spectrum efficiency and encourage innovation. In its 1999 Spectrum Policy Statement, the Commission explicitly recognized its responsibility to "encourage the development and deployment of new, more efficient technologies that will increase the amount of information that can be transmitted in a given amount of bandwidth."[32] AT&T Wireless supports the Commission in this mission, but is concerned that the current narrow focus on the benefits of unlicensed technologies and the desire to advance them is obscuring the innovations taking place in the CMRS industry and would, in fact, discourage future innovation.

1. The CMRS industry has been an innovation "success story."

The history of CMRS is one of continuing innovation and increasing spectral efficiency. The Spectrum Policy Task Force Report explicitly recognized the benefits of the exclusive use model of spectrum management for promoting technical and economic efficiencies, and

[32] *See Principles for Reallocation of Spectrum to Encourage the Development of Telecommunications Technologies for the New Millenium,* FCC 99-354, Policy Statement (rel. Nov. 22, 1999) ("Spectrum Policy Statement") at 3.

specifically identified CMRS licensees as an example of how that approach can maximize spectrum use.[33] The Report's conclusion is verified by Figure 1 below, which shows the capacity gains the CMRS industry has achieved by continually developing more spectrum efficient technologies.

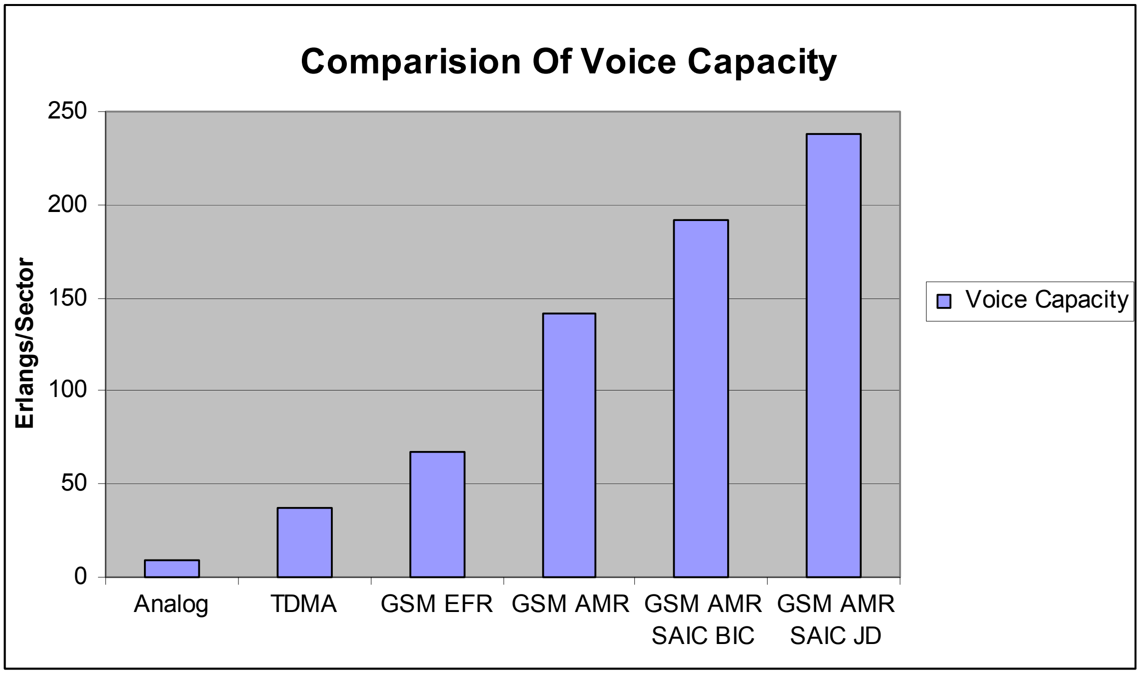

FIGURE 5[34]

Importantly for the issues addressed in the *NOI*, the improvements associated with the last two stages (SAIC gains) in this chart would have been rendered difficult or impossible in an interference-temperature limited environment.[35]

[33] SPTF Report at 36-37. In fact, referring to the CMRS bands, the Report noted: "[b]ecause many of the benefits of flexibility have already been realized in these bands, and spectrum uses have developed accordingly, there is not a significant need for fundamental regulatory changes in these bands in the near term." *Id* at 47.

[34] Figure based on Peter Rysavy, "Voice Capacity Enhancements for GSM Evolution," July 18 2002," figure 6, p. 14 ("Rysavy White Paper"), and Mark Austin, ed., "SAIC and Synchronized Networks for Increased GSM Capacity," September 2003, figure 4.2.2, p. 16.

[35] *See infra* section II.A.2.

Over the past decade, the CMRS industry has developed a host of technologies to improve spectrum efficiency, reduce interference, and raise capacity and service quality.[36] Some examples include Adaptive Modulation Rate ("AMR"), frequency hopping in GSM, EDGE, and most recently HSDPA, an enhancement being developed to increase the efficiency and throughput of W-CDMA systems. The result of many of these developments has been to drive receivers' threshold sensitivity levels lower and lower – closer and closer to the thermal noise level for TDMA systems including IS-136 and GSM, and even below the thermal noise floor for CDMA systems. The introduction of an interference temperature limit could negate many of the gains the industry has made over the past several years by reducing the margin available to achieve these capacity gains.

2. Establishment of an Interference Temperature Limit in the CMRS bands would undermine incentives for future innovation.

One of the key assumptions underlying the Commission's interference temperature concept is that there is unused "information capacity" that is currently underutilized and that could be occupied by unlicensed devices.[37] AT&T Wireless disputes that notion (*see* Section II.A.3) and notes that the CMRS industry is developing technologies today that seek to make even more effective and efficient use of that information capacity. In this context, the Commission must not only carefully consider the impact that the imposition of an interference temperature limit would have on the development of those technologies but on the impacts on future innovation as well.

AT&T Wireless is concerned because while the application of an interference temperature limit would establish a theoretical "ceiling" on the amount of energy that could be

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[36] *See* generally Rysavy White Paper.

[37] Using the Hartley-Shannon definition that information capacity is a function of bandwidth and C/I. *See* C. E. Shannon, The Mathematical Theory of Information (Urbana, IL: University of Illinois Press, 1949) (reprinted 1998).

put into a band by unlicensed devices, it would simultaneously impose an irreducible noise or interference "floor" below which the licensee would have no protection and little incentive to develop. From a strict regulatory perspective, it appears that the interference temperature limit, while not a "hard" limit for incumbent licensees, would function as one in practice. With that portion of the information capacity targeted for unlicensed use, licensees transmitting below the interference temperature limit would be subject to interference from unlicensed, underlay devices without recourse; they would essentially become co-primary or secondary users under the limit. In such a circumstance, licensees will be unwilling to invest in technologies that can make the maximum use of the power range if there is no sustainable benefit. The Commission tacitly acknowledges this impact, noting that "[i]nterference temperature limits could also serve as a 'worst' case characterization of the RF environment that would provide benchmarks of the operating environment for equipment and system designers."[38]

The establishment of an interference temperature limit in order to reserve spectral space for unlicensed devices thus effectively puts "off limits" a portion of the licensee's authorized spectrum, creating a dead zone in which a licensed carrier would not be able to operate reliably or use to develop more spectrum-efficient or capacity-enhancing techniques.[39] Such a forced carveout would remove part of the information capacity that licensees are increasingly using to improve service and add capacity, and would seemingly contradict the Commission's desire "to provide opportunities for an ever increasing array of new digital radio technologies and services and to allow *licensees* to implement and modify these new technologies and services in accordance with the demands of market forces…"[40] By decreasing the information capacity available to licensed operators, opportunities for innovation necessarily decrease.

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[38] *NOI* at ¶ 15.

[39] This is the space referred to in the *NOI* as "New Opportunities for Spectrum Access." *Id*.

[40] *Id.* at ¶6 (emphasis added).

It should also be noted that the Commission seems to assume that underlay devices will operate all the time and will continuously occupy the "unused" space the Commission is trying to fill. This seems unlikely to be the case except in the most densely device-populated areas. Under the current interference temperature concept, that spectrum would then lie fallow, waiting for an unlicensed device to use it. Simultaneously, however, the licensed user would have little incentive to invest in the technology to use that portion of the dynamic range available for fear of ever being able to use it effectively or without experiencing significant levels of interference. Thus, the interference temperature concept could ironically create the very problem it is trying to solve—"unused" information space.

IV. ENFORCEMENT OF AN INTERFERENCE TEMPERATURE LIMIT WOULD BE IMPOSSIBLE IN PRACTICE.

A. Effective Enforcement After the Fact Is Unrealistic.

If devices authorized pursuant to the interference temperature concept do enter the marketplace and cause interference that cannot be mitigated, regulatory enforcement after-the-fact would be virtually impossible. As AT&T Wireless has previously explained:

> While the [Spectrum Policy Task Force] Report notes that effective enforcement is "an essential component" necessary for interference temperature-enabled underlay operations, it proposes no recommendations to address the futility licensees experience today in pursuit of interfering devices that are itinerant, unlicensed, and unidentifiable. As the Report even acknowledges, once devices are introduced into the marketplace, "it may be difficult legally or politically to shut down their operations *even if they begin to cause interference or otherwise limit the licensed user's flexibility.*"[41]

The very characteristics that make unlicensed underlay devices potentially useful also make them particularly troublesome from an interference enforcement perspective:

- Ubiquitous—with widespread adoption, interference is a potential problem in most places; this factor is immensely more complicated when the licensed service's users are mobile, as in the case with CMRS;

[41] AT&T Wireless SPTF Report Comments at 12 (emphasis added).

- Varied—with many designs and technical/operating characteristics, the mechanisms for interference will be similarly varied and challenging. Some devices could be particularly "bursty" with energy peaks that rise above the interference temperature limit, but only for short periods of time—just long enough to disrupt licensed operations but not long enough for amelioration or identification.
- Mobile—the devices, and the interference they cause, may be itinerant in many cases, making them extremely difficult to locate or engineer around;
- Anonymous—with different characteristics, no geographic address, and the capacity to move, identifying a specific interfering device or class of devices could be almost impossible.

The combination of these factors puts the licensed operator in a difficult situation: it encounters multiple types of interference across its service area, the interference moves around in space and time, and the sources of the interference cannot be located or predicted. Many commenters have noted the enforcement challenges in such a situation, especially when devices are mobile in nature and their transmissions are intermittent.[42]

Even if all these difficulties were to be surmounted, and interfering devices could be identified, the Commission would face a serious challenge if underlay devices that caused harmful interference were introduced into licensed spectrum. Once unlicensed devices are sold, they become virtually untraceable—and practically immune to recall. Indeed, this is the very case the Commission faced in 2002 with radar detectors causing interference to VSATs.[43] The Commission was forced to grandfather previously sold radar detectors even though they produced

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[42] *See, e.g.,* Comments of Cox Broadcasting, Inc. at 7; Comments of APCO at 2; Comments of Cingular Wireless LLC at 9; Comments of the Rural 700 MHz Band Licensees at 5, *Additional Spectrum for Unlicensed Devices Below 900 MHz and in the 3 GHz Band,* ET Docket No. 02-380 (May 16, 2003).

[43] *See Review of Part 15 and Other Parts of the Commission's Rules*, First Report and Order, 17 FCC Rcd 14063, 14067 ¶ 11 (2002).

harmful interference, and could only act to stop interference from future devices.[44] Such action, of course, does nothing to cure the interference that will continue from the existing legacy base of equipment. The situation the Commission faces here is the same; if interfering devices are implemented and the interference damage is done, there will be little the Commission can do after the fact.

B. The *NOI's* Questions Belie Its Assertions of Certainty for Licensees.

The Commission asks what actions underlay devices should take when the interference temperature limit is exceeded.[45] In that discussion, the Commission recognizes that if the interference temperature concept were adopted, there would be cases in which one or more unlicensed devices will exceed the cap and cause interference to the incumbent services, and asks what should be done in those cases. Far from providing the certainty to existing licensees that the Commission declares as one of the primary considerations in this proceeding, these questions undercut one of the fundamental assumptions of the concept itself—that no interference will occur. Particularly troubling is the Commission's request that commenters "seek to balance the requirement that the temperature limits are not exceeded against the need for devices to maintain communications."[46] In this case, there should be no such "balance." The interference temperature concept, and the part 15 rules that will govern unlicensed devices, are quite clear, such devices may not cause interference and must accept any interference they receive. Primary

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[44] The Commission imposed radiated emission limits on newly marketed radar detectors but did not take any steps to protect VSATs from interfering detectors already in the marketplace. As the decision noted, "identifying [these] radar detectors is not practical . . . because these devices are mobile and therefore interfere intermittently. Further . . . in most cases it is not possible for the [victim operator] to remedy the interference even if the source could be identified" because these devices are not controlled by the victim operator. *Review of Part 15 and Other Parts of the Commission's Rules*, First Report and Order, 17 FCC Rcd 14063, 14067 ¶ 11 (2002).

[45] *NOI* at ¶ 23.

[46] *Id*.

licensees, like AT&T Wireless, fully expect that the Commission will provide the certainty it promises, and will not adopt a concept it acknowledges will cause interference.

CONCLUSION

For the reasons discussed above, AT&T Wireless respectfully submits that the Commission must consider carefully the introduction of unlicensed underlay devices within the framework of an interference temperature limit and should only place such devices in spectrum bands dedicated for unlicensed use. Given the conceptual and practical difficulties with the interference temperature concept, an interference temperature limit will not be workable in the CMRS bands. Further, because of the very direct harms to existing CMRS consumers and licensees that will occur as a result of the imposition of an interference temperature limit, and the lack of any practical way to enforce the Commission's rules regarding interference before or after the fact, under no circumstance should the Commission consider introducing underlay technologies into spectrum licensed for mobile services and for CMRS in particular.

Respectfully submitted,

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